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EVALUATION OF AN INSULATED, HEATED MEDICAL PANNIER FOR USE IN T--ETC(U)
JAN 78 G P UNDERWOOD, R J OSCZEVSKI

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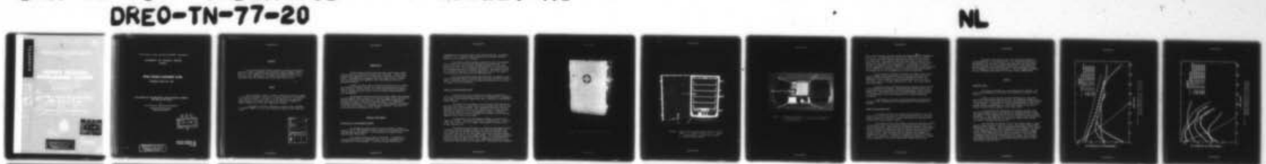

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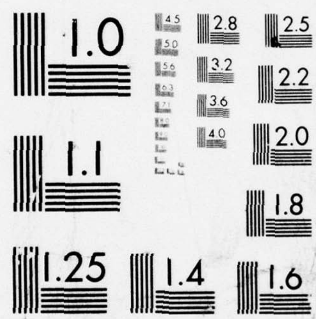

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EVALUATION OF AN INSULATED, HEATED MEDICAL PANNIER FOR USE IN THE FIELD.

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EVALUATION OF AN INSULATED, HEATED MEDICAL PANNIER FOR USE IN THE FIELD

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G.P. Underwood, R.J. Osczevski and J.M. McAndless

Environmental Protection Section
Protective Sciences Division

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ABSTRACT

An insulated heated pannier, developed in Norway, was laboratory and field tested to determine its suitability against Canadian requirements for a unit capable of protecting medical supplies against the effects of cold temperatures. At ambient temperatures as low as -40°C the pannier kept the contents warm, pliable and ready to use.

RÉSUMÉ

Une infirmerie portative isolée et maintenue au chaud, produite et assemblée en Norvège, a été mise à l'épreuve aussi bien en laboratoire qu'en terrain d'essai. Ceci dans le but de déterminer ses capacitées quant au besoin du Canada d'avoir une unité capable de protéger le matériel médical de l'effet des températures froides.

L'infirmerie portative a maintenue le contenu chaud, malléable et d'emploi immédiat et ceci à une température ambiente aussi basse que -40°C.

INTRODUCTION

Canadian Forces medical field units must protect their liquid supplies from low temperatures during winter operations. Certain items undergo phase separation or even rupture their containers if allowed to freeze. Injectable and intravenous solutions should, in fact, be kept near body temperature for immediate use by Unit Medical Stations or Evacuation Platoons.

Panniers currently used by the Canadian Forces for unit storage and transport of medical supplies are simple, uninsulated metal boxes. They are durably constructed and do provide adequate physical protection for the contents but offer little, if any, protection from freezing in cold environments.

The Norwegian Defence Research Establishment (NDRE) has developed a heated medical stores container for field use under winter conditions (1). DREO obtained one of these panniers on loan from NDRE for laboratory testing, the results of which are described herein. To determine the operational suitability of the pannier in satisfying Canadian requirements, it was also field tested by 2 Field Ambulance personnel. The results of the field trial are included in this report.

MATERIALS AND METHODS

Description of the Norwegian Pannier

The Norwegian-developed medical stores container is shown in Figures 1 and 2. The container consists basically of a plywood box having six removable plastic shelves. It is insulated with sheets of polyurethane foam, 30 mm thick.

Two separate heating systems are available. A thermostated resistance-wire system is permanently built into the container and is used where 24 V dc is available. A charcoal heating system that is

independent of any external power source is also provided. As shown in Figures 2 and 3, a separate drawer containing the charcoal system is inserted at the bottom of the pannier.

The charcoal heating system is powered by two D-size batteries and is fuelled by a charcoal stick encased in an aluminum can. The batteries are used both to ignite the fuel by means of a fuze and to power a small fan. The fan supplies combustion air to the fuel as well as circulating heated air throughout the pannier. Heat output from the fuel canister is regulated by a thermostat which controls the speed of the fan and thus the rate of flow of combustion air.

The charcoal heating system described above is similar to the system developed by NDRE for heating radio batteries used with the PRC 77 radio. Detailed descriptions of the charcoal heating system (1, 2) and the pannier itself are available.

Conduct of the Laboratory Tests

The objectives of this phase of the pannier testing were to verify the reported performance of the unit, to determine fuel consumption rates under various ambient temperatures and to identify any unacceptable design features.

The ability of the pannier to protect fluids from freezing was measured by recording the temperatures of the contents while the unit was operating under cold conditions. Fuel consumption rates were found by measuring the temperature of the fuel canister itself to determine when the fuel was exhausted. After approximately 400 hours of operation, which was more than sufficient to become fully familiar with the pannier, comments could be made on its design.

A Tenney Model TR-14 environmental chamber was used for all laboratory testing. The pannier was tested at temperatures of -20°C and -40°C. Due to the size of the chamber, the pannier was tested in the upright position only.

The pannier was filled with 14 l of dextrose and sodium chloride intravenous solution packaged in 500-ml and 1000-ml polyethylene bags. It was found that an average temperature for the unit occurred at the third shelf from the top, as the contents above this shelf were slightly cooler and those below it were slightly warmer. For recording convenience therefore, only the temperatures of the fluids on the third shelf were monitored during this part of the work. Temperature variation from top to bottom of the container did not exceed 3°C. Temperatures were measured

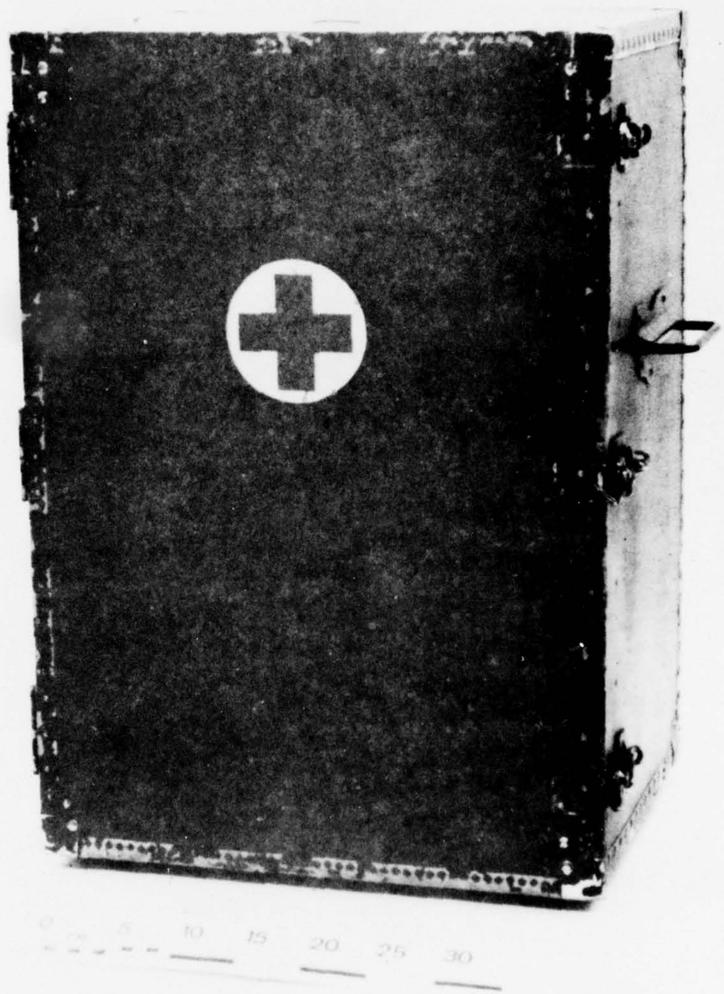

Figure 1. Exterior View of Norwegian Pannier.

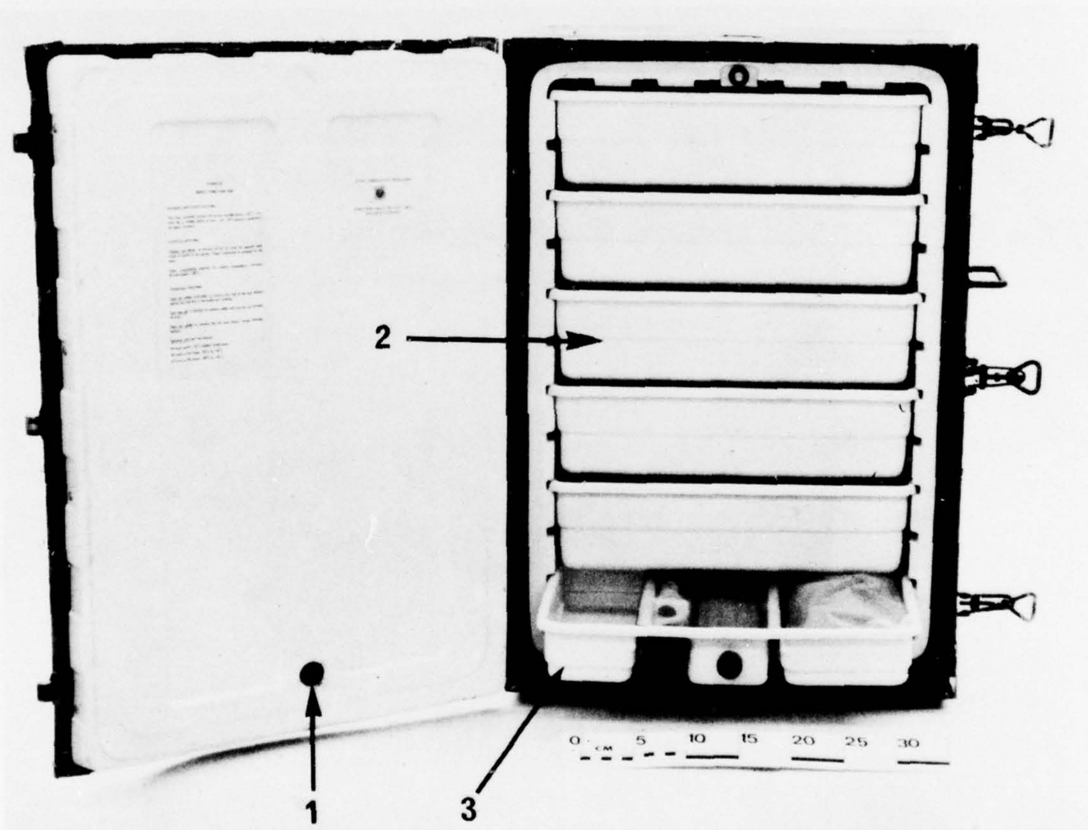

Figure 2. Pannier with Door Open Showing Charcoal Heating Drawer. 1. Exhaust gas exit hole. 2. Drawer where temperatures of contents were measured. 3. Charcoal heating drawer.

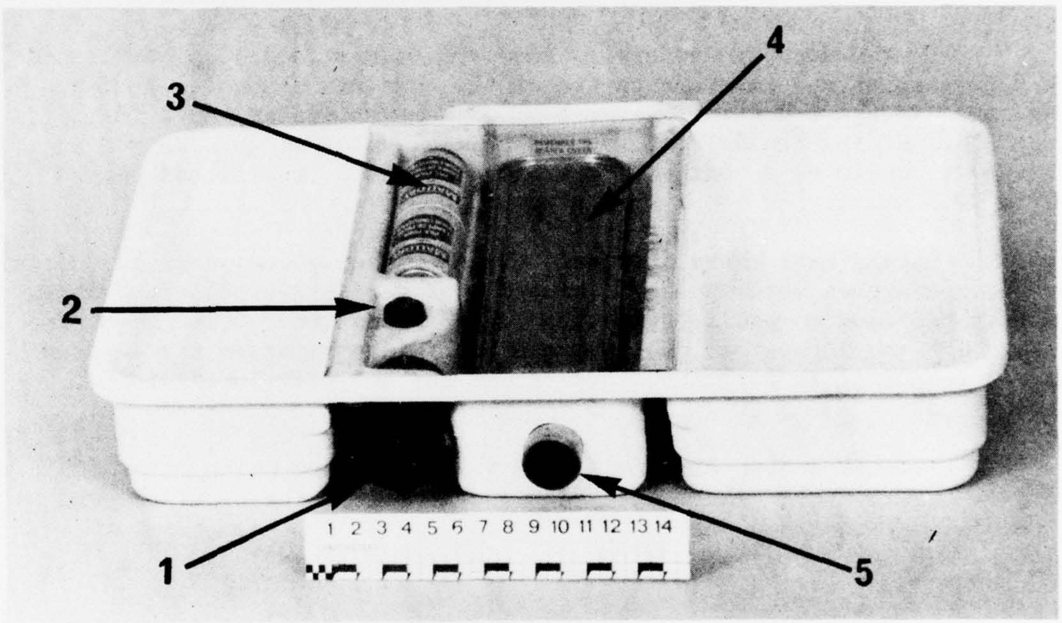

Figure 3. Charcoal Heating Drawer. 1. Fan 2. Ignition button. 3. D-size batteries. 4. Charcoal fuel element. 5. Exhaust gas exit.

with a Yellow Springs Instrument Corporation Thermistemp® Tele-Thermometer, Model 42 SF. The thermistor of this unit was taped to the top surface of a 500-ml intravenous solution bag which was located in the center of the third shelf. The thermistor wires were fed under the seals of the pannier door and chamber door and connected to an external recorder which provided a continuous trace of temperature. By measuring the outside surface temperature of the fuel canister at one end using a second thermistor it was possible to determine when all of the charcoal had been consumed. The average rate of fuel consumption could then be calculated.

On two separate occasions the pannier was loaded, placed inside the cold chamber and the temperature of the contents monitored in the absence of internal heating. At a chamber temperature of -40°C the temperature of the fluids fell from an initial value of 20°C to 0°C in 13.5 hours, while at a chamber temperature of -20°C, the fluids reached 0°C in 20.5 hours.

During runs where internal heating was supplied, various initial fluid temperatures were chosen. Several runs were performed after the contents had come to equilibrium with room temperature. Other runs were carried out in succession; that is, the initial temperature for a given run was identical to the final temperature for the test immediately preceeding.

A small number of trials were also performed using electrical heating. Power requirements and the temperatures of the contents were recorded.

Conduct of the Field Trial

The pannier was also field tested as a supplement to the laboratory work. The unit was given to 2 Field Ambulance for use on exercise Perfect Season III, 18-27 Jan 77, held in and around the training area at Canadian Forces Base Petawawa, Ontario.

As potential users of the pannier, the medical personnel involved in the exercise were best qualified to determine how the unit should be realistically tested. DREO requested that ambient temperatures be recorded and that subjective comments be collected covering both the capabilities of the unit under cold conditions and its apparent suitability for the Canadian Forces. DREO instructed that the charcoal fuel elements be changed every 24 hours as detailed fuel-consumption data would be determined in the laboratory. In addition, changing fuel elements on a regular basis, regardless of the ambient temperature, simplified the trial.

The pannier was tested by one of the Evacuation Platoons of 2 Field Ambulance. It was stocked with 3 l of intravenous solution and approximately 3 kg of various creams, injectables and solutions during all field testing. The unit received full exposure to the prevailing weather conditions and on different occasions was transported by truck and by toboggan on cross-country marches. A mercury-in-glass thermometer was used to measure both ambient and interior pannier temperatures.

RESULTS

Laboratory Tests

The pannier performed well during this phase of testing. Only minor icing problems were encountered, as discussed at the end of this section.

Figures 4 and 5 show the recorded temperatures of the fluids versus time when charcoal heating was used. For comparison purposes, the rate of heat loss of the contents without internal heating is also indicated in these Figures. As expected, at an external temperature of -20°C, the pannier contents remained warm for a much longer period of time with or without charcoal heating compared to the case at -40°C.

At a given external temperature, the charcoal heating system effectively supplied heat to the contents for differing periods of time, the length of which depended upon the initial temperature of the contents themselves. It was considered that heat was no longer supplied effectively to the contents when their rate of cooling was similar to the cooling rate where no internal heating was used.

As illustrated by Figures 4 and 5, the contents tended to remain warm for longer periods of time with charcoal heating when their initial temperatures were higher. This is expected when the relative heat contents of the fluids at different initial temperatures is considered. At lower initial temperatures (lower heat content) the charcoal heater consumes fuel at a high combustion rate to warm the contents to the point where thermostatic control of the combustion process occurs. Thus, the fuel is expended sooner compared to cases where the contents are relatively warm initially and the fuel can be consumed from the outset at a thermostatically-controlled rate.

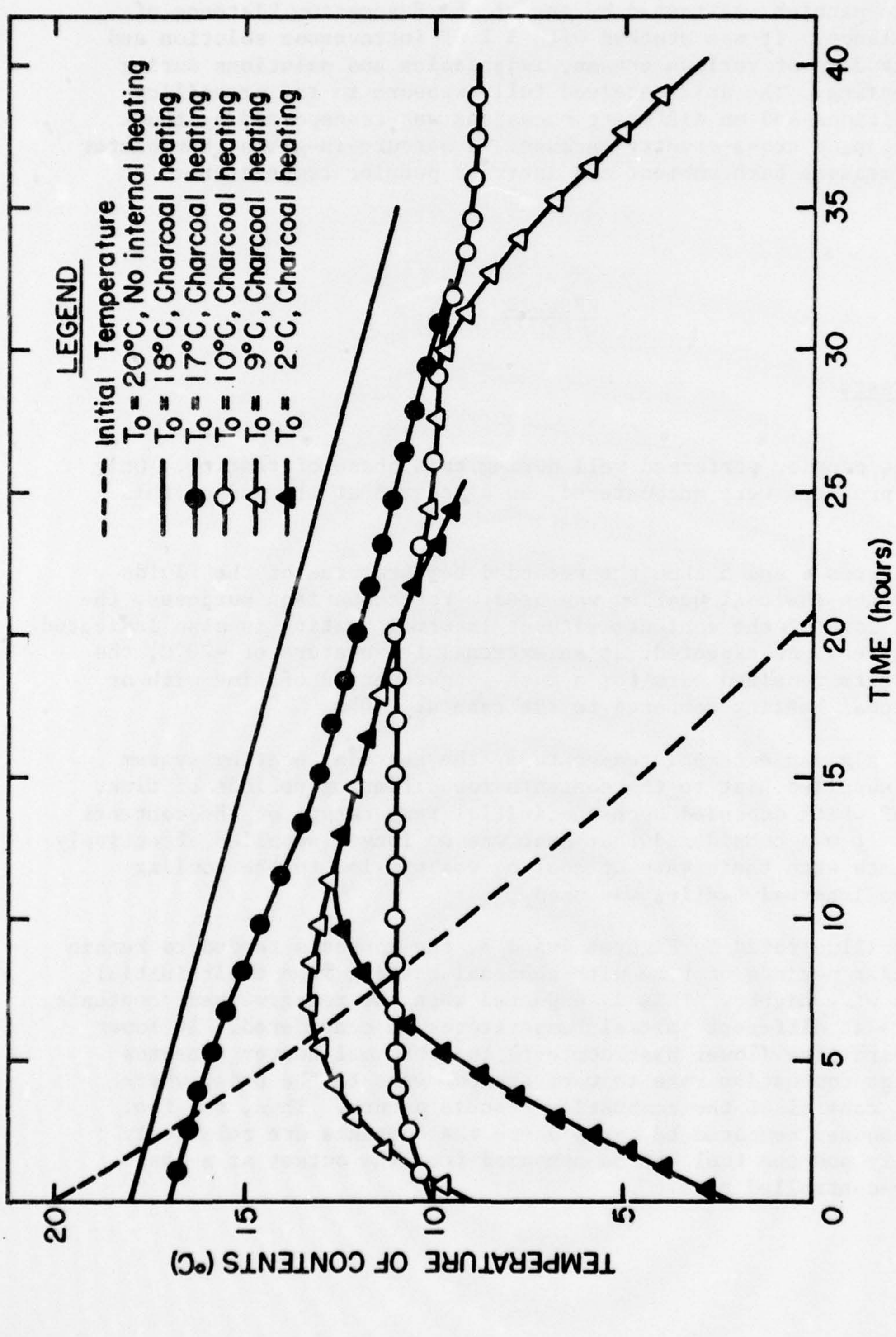

Figure 4. Recorded Temperatures of Contents with Charcoal Heating at -20°C. Each curve represents heating by one fuel element.

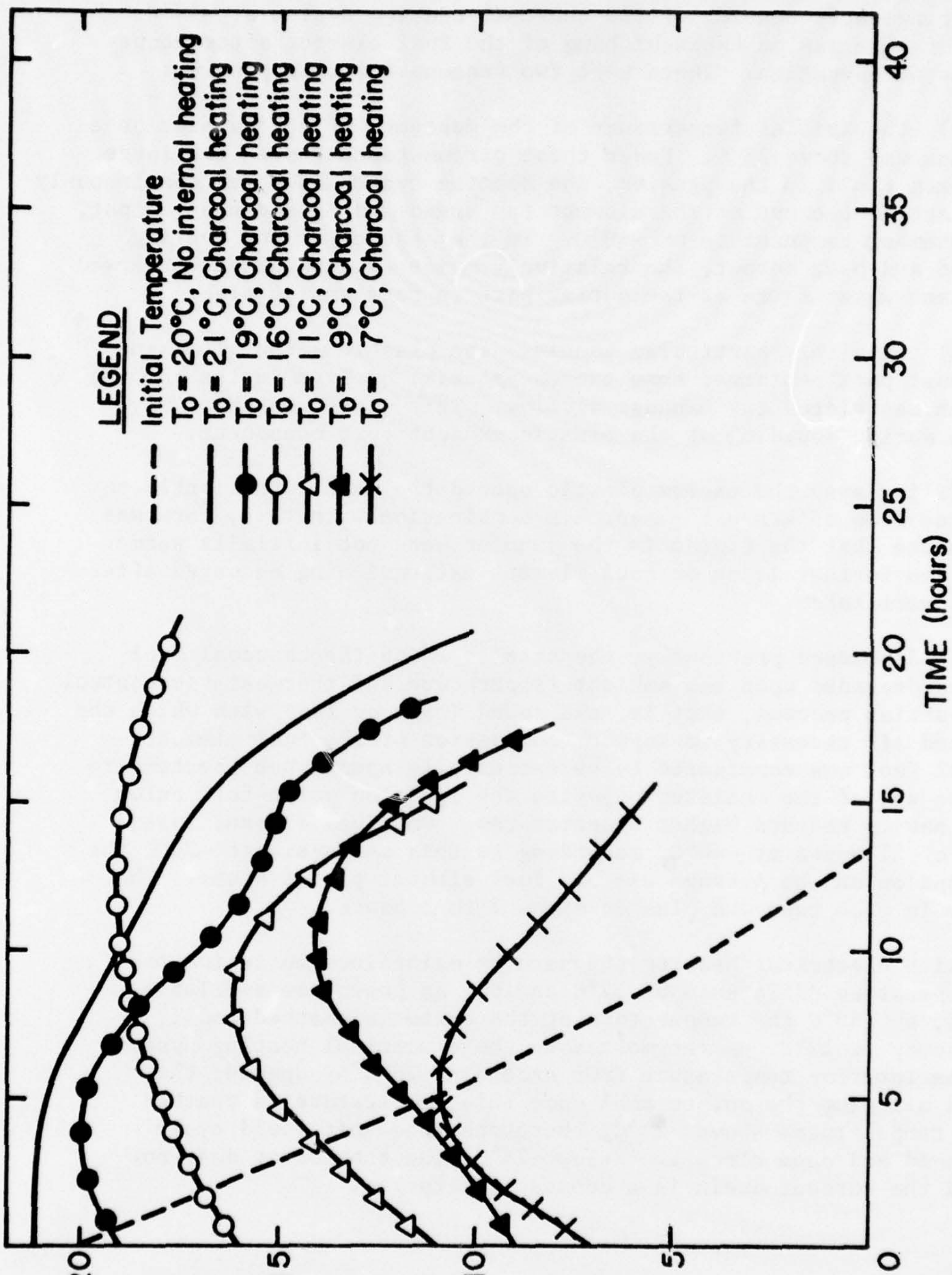

Figure 5. Recorded Temperatures of Contents with Charcoal Heating at -40°C. Each curve represents heating by one fuel element.

Icing of the exhaust port on the door of the pannier (Figure 2) occurred during early testing of the charcoal heating system at -40°C. The result of this was an extinguishing of the fuel element after about 2 to 4 hours of operation. There were two reasons for this problem:

a) the initial temperature of the contents of the pannier on a few occasions was above 23°C. Under these circumstances, with the large volume of warm fluid in the pannier, the heating system operated continuously from the start of the run at the slowest fan speed and lowest heat output, even at a chamber temperature of -40°C. In the absence of any cycling in fan speed and heat output, the relatively moist exhaust gases condensed and sufficient water froze at the outlet port to form an ice plug.

b) with this particular pannier, the plastic material making up the exhaust port contained some excess material or burr in the opening itself which restricted the exhaust airflow. This excess material may have arisen during moulding of the plastic exhaust port component.

Filing away the excess plastic opened the hole sufficiently to permit a free flow of exhaust gases. In combination with this, care was taken to ensure that the fluids in the pannier were not initially warmer than 21°C. No further icing or fuel element extinguishing occurred after these steps were taken.

As discussed previously, the rate at which the charcoal fuel was consumed depended upon the ambient temperature and thermostatic control of the combustion process, that is, the speed (high or low) with which the fan delivered air necessary to support combustion of the fuel element. The charcoal fuel was considered to be essentially spent when the temperature at the end of the canister opposite the ignition point fell below 75°C after having reached higher temperatures. One fuel element lasted an average of 21 hours at -40°C, according to this measure. At -20°C the fuel comsumption on the average was one fuel element per 46 hours. The variability in each case was plus or minus 2 to 3 hours.

With electrical heating the pannier maintained an inside-to-outside temperature difference of 52°C as long as power was available. For example, at -40°C the temperature of the contents reached and remained steady at 12°C. A thermostat in the electrical heating system prevents the interior temperature from exceeding 26°C by opening the circuit and allowing the box to cool once this temperature is reached. At ambient temperatures above -26°C, therefore, the unit would cycle between closed and open circuit. Below -26°C, the thermostat does not operate and the current drain is a constant 2 amperes.

Field Trial

A report on the field trial conducted by 2 Field Ambulance is contained in Appendix A. Paragraph 4a refers to ice forming at the bottom

of the pannier. It is felt that the water originated from the fuel element as in the case of the laboratory tests and was not due primarily to opening and closing the door. The moisture content of the charcoal is such that each element contains several grams of water. This can be taken up by the warm combustion flow and later condensed and frozen on the cold bottom surface of the pannier.

DISCUSSION

The times and temperatures given in this report are specific to the experimental conditions used. In other situations a number of variables not accounted for in these tests may influence the operation of the unit. Such factors as quantity of supplies, their heat capacity, solar radiation and wind chill effects will all affect the pannier and its heating systems to some extent. Although the test results are limited, the information presented is a good indication of the general performance capabilities of the pannier.

From Figures 4 and 5 it is evident that, with charcoal heating, the contents of the pannier are well protected from freezing at ambient temperatures as low as -40°C. The downward sloping curves shown on these Figures indicate, however, that the heat transfer efficiency from fuel element to air flow diminishes with time. The design of the heating drawer is such that the recirculating air flow provided by the fan draws heat from the fuel element most efficiently when the fuel is only partially consumed. During the later stages of operation progressively less heat is transferred to the moving air due to the flow patterns over the element. This accounts for the fact that the fuel element itself can still be quite warm even though the temperature of the contents is falling rapidly. Although it would be possible to extract heat from the fuel element more efficiently this would certainly add to the complexity and cost of the unit. One of the desirable features of the charcoal system is its simplicity. It is felt that the Norwegian design strikes a good balance between low cost and effective operation.

The price of each charcoal fuel element is expected to be approximately $10.00. Thus, fuel costs on a typical winter operation could range from $5.00 to $20.00 per day depending on ambient temperature, availability of shelter for the pannier, quantity and heat capacity of the contents. With electrical heating a constant power consumption of 48 watts occurs at temperatures below -26°C.

The exact operation time of each charcoal fuel element can easily be verified by the operator. The position of the combustion front in the fuel can be checked by carefully touching the canister and determining where it is hottest. From this an estimate of the remaining life of the fuel can be made. When the combustion front reaches the opposite end of the element from where it was ignited then the operator should change the fuel canister. In this way re-fueling would occur at optimum intervals according to the prevailing conditions using the suggested operation times on the unit and data in this report as guides.

The icing problems encountered during testing are considered to be of a minor nature. It is important, however, to ensure that the exhaust flow is unrestricted. The combination of a large volume of warm fluids, a low ambient temperature and a restricted flow was sufficient to cause a blockage, as previously mentioned. Generally, this can be remedied by ensuring that the exhaust gas hole does not contain a burr of plastic. In addition, large volumes of fluids should not initially be warmer than 20°C when placed in the pannier.

The pannier was well received by the medical personnel during field testing. It was found to be simple to operate and required only a brief introductory explanation and demonstration. 2 Field Ambulance pointed out a minor problem with the D-size batteries coming loose from their positions. This problem could be easily remedied if the unit were supplied with a suitable battery clip.

When transporting the pannier while on foot, the box should not be strapped to the top of a fully loaded toboggan as this will certainly result in overturning. Although this did occur in the field trial, the pannier was sufficiently robust to withstand such treatment. To accommodate the shape of the toboggan and prevent tipping, the pannier can be placed on its side. This position did not adversely affect the operation of the charcoal heating system during the field trial although this was not specifically verified in the laboratory. Whenever possible, the pannier should be used in the upright position with charcoal heating to ensure efficient convection flow of air. The orientation of the unit with electrical heating is unimportant.

The overall assessment of the pannier and the heating systems is that they are simple yet effective in protecting the contents against the effects of low temperatures.

CONCLUSIONS

1. The overall design of the pannier and its charcoal and electrical heating systems is simple and effective for the purpose of protecting medical supplies from freezing under extreme cold conditions.

2. On the average, one charcoal fuel element keeps the contents from freezing for approximately 47 hours at -20°C or 27 hours at -40°C if the contents have an initial temperature above 10°C. The length of time the contents are supplied with heat from the charcoal fuel depends on the initial temperature of the contents themselves as well as the ambient temperature.

3. In the absence of internal heating the temperature of the contents falls from 20° to 0°C in 20.5 hours and 13.5 hours at ambient temperatures of -20°C and -40°C respectively.

4. With electrical heating, an inside-to-outside temperature difference of 52°C and/or an internal maximum of 26°C occurs. At ambient temperatures below -26°C, the electrical heating system consumes 48 watts.

ACKNOWLEDGEMENTS

We wish to thank the Norwegian Defence Research Establishment and Dr. T.A. Oftedal for providing the pannier to DREO.

The assistance of Major K.R. Nickerson, Directorate of Preventive Medicine, in making arrangements for the field trial is appreciated.

The help of 2 Field Ambulance in providing a realistic field trial for the pannier is also acknowledged.

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1. E. Melvaer, B. Nordli and S. Rustad, Norwegian Defence Research Establishment, Intern rapport VM 47, October 1976.
2. B. Nordli, T.A. Oftedal and E. Wulvik, Norwegian Defence Research Establishment, Intern rapport VM 24, November 1973.

APPENDIX A

The following is a summary of results from the field trial carried out by 2 Field Ambulance at CFB Petawawa. These results were reported to DREO by the Director of Preventive Medicine, National Defence Headquarters.

NORWEGIAN HEATED PANNIER

1. This unit was included in our medical load table and subjected to field conditions during Exercise Perfect Season III, 18-27 Jan 77.

2. The unit was stocked with perishable medical items which required protection from the cold and placed outside our modular canvas and subjected to local weather conditions. During road moves, the unit was placed in the back of a 2½-ton vehicle and tied in position.

3. Throughout the testing period, we found this unit simple to operate and no difficulties were encountered. Each charcoal heating element ignited without delay and continued to burn for the prescribed 24-hour period.

4. Two minor problems were encountered throughout the testing period:

a. It was noticed that small amounts of ice were forming on the outside of the bottom portion of the pannier directly underneath the exhaust outlet on the bottom drawer, and had to be removed daily. This minor problem was probably due to condensation caused by opening the unit several times per hour, totalling an open time per hour of 1-3 minutes, to monitor the interior temperature;

b. On three occasions it was noticed that small particles of carbon soot had infiltrated the compartments of the pannier causing the unit to become dirty. (NB: All charcoal units were burned approximately two minutes prior to being inserted in the drawer.)

5. For the duration of the testing period a Taylor thermometer with an indoor and an outdoor scale was used. The thermometer was placed in the second drawer from the top and the internal cable and mercury-containing element taped to the outside of the unit and exposed to the ambient air.

6. Temperatures were checked hourly and recorded to arrive at a daily average.

	Outside	Inside
17 Jan	-26°C	12°C
18 Jan	-19	14
19 Jan	-08	13
20 Jan	-10	14
21 Jan	-15	13
22 Jan	-16	14
23 Jan	-15	12
24 Jan	-10	14
25 Jan	-11	13
26 Jan	-12	12
27 Jan	-17	14

7. As part of the test program the pannier was placed on a toboggan and taken on a cross country compass march. This caused the toboggan load to be bulky, making the toboggan a little more difficult to handle and prone to upsetting.

8. During road moves the pannier was placed in the back of our 2 ½-ton vehicle and tied in position along with our other medical and surgical panniers. The unit caused no noticeable difference in the configuration of our load table and even with our limited space, no problems were presented.

9. During the test period the unit was not subjected to any undue misuse. However, while on our cross country compass march, it was lashed to the top of the toboggan and on four or five occasions the toboggan toppled, causing the unit to be subjected to undue stress and strain (loaded toboggan weighs approximately 200 lbs). No noticeable damage occurred and the pannier appears to be durably constructed for use in the field.

10. Throughout the period the pannier was employed in a testing capacity only and no occasion arose in which the contents had to be used. When tested, the ointments appeared ready to use and the consistency pliable. The injectibles were warm to touch and ready to use with little rewarming.

11. It was observed on our compass march that the two D-cell batteries used to power the unit were sometimes jarred out of alignment. This caused no interruption in the circulating unit but the batteries had to be placed back in position manually.

12. The compartments in this pannier are much larger than those in the battle box and small items such as vials and small bottles were scattered and had to be protected by wrapping in gauze.

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